PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 6G-99	**FOR FUTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No PCT/RU 99/00149	International filing date (day/month/year) 30 April 1999(30.04.99)	Priority date (day/month/year) 30 April 1998 (30.04.98)
International Patent Classification (IPC) or national classification and IPC	H01J 1/30, H01J 9/02	
Applicant GIVARGIZOV Evgeny Invievich et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant accoding to Article 36

2. This Report consists of a total of 3 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claimes and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70/16 and Section 607 of the Administrative Instructions under PCT).

These annexes consist of a total of _____ sheets

3. This report contains indications relating to the following items:

I ☒ Basis of the report

II ☐ Priority

III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

IV ☐ Lack of unity of invention

V ☒ Reasoned statement under Articl 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

VI ☐ Certain documents cited

VII ☐ Certain defects in the international application

VIII ☐ Certain observations on the international application

Date of submission of the demand: 28 October 1999 (28.10.99)	Date of completion of this report: 08 June 2000 (08.06.2000)
Name and mailing address of the IPEA/ RU Federal institut of industrial property Russia, 121858,Moscow,Berezhkovskaya nab., 30-1 Facsimile No.	Authorized officer O. Bednaya Telephone No 240-2591

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No
PCT/RU 99/00149

1. Basis of the report

1. With regard to the **elements** of the international application:*

☒ the international application as originally filed

☐ the description:

pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

☐ the claims:

pages _____, as originally filed
pages _____, as amended (together with any statement) under Article 19
pages _____, filed with the demand
pages _____, filed with the letter of _____

☐ the drawings:

pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

☐ the sequence listing part of the description:

pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
☐ the language of publication of the international application (under Rule 48.3 (b)).
☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.
☐ filed together with the international application in computer readable form.
☐ furnished subsequently to this Authority in written form
☐ furnished subsequently to this Authority in computer form.
☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed been furnished.
☐ The statement that the information recorded in computer readable form is identical to the sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:
☐ the description, pages _____
☐ the claims, Nos. _____
☐ the drawings, sheets/fig _____

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Bof (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an iinvitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No
PCT/RU 99/00149

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicabillity; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-50	YES
	Claims		NO
Inventive step (IS)	Claims	1-50	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-50	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

Claims 1-9, 10-21 meet the criteria of novelty and inventive step since documents cited in the search report don't disclose an electron source, wherein the field emitter is implemented of a whisker epitaxially grown on the substrate and at least one ballast resistor is implemented as a barrier which is represented as a boundary in the body of the field emitter, the boundary being formed by contact of materials with different kinds of conductivity or a barrier formed by a boundary between a field emitter body and a conducting layer placed on the surface of the field emitter.

Claims 22-25 meet the criteria of novelty and inventive step since documents cited in the search report don't disclose an electron source, wherein the substrate has a shape of a tip and is formed by insulator and by a conductive layer, the ballast resistor is implemented by the layer.

Claims 26-38 meet the criteria of novelty and inventive step since documents cited in the search report don't disclose a controlled electron source implemented according to claims 1-25.

Claims 39-43 meet the criteria of novelty and inventive step since documents cited in the search report don't disclose a matrix system of the controlled electron source implemented according to any of the claims 26-38.

Claims 44-50 meet the criteria of novelty and inventive step since documents cited in the search report don't disclose a method for preparation of controlled electron source, wherein the field emitters are implemented of whiskers epitaxially grown by the vapor-liquid-solid mechanism.

ENT COOPERATION TRE,

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING SUBMISSION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

GIVARGIZOV, Evgeny Invievich
ul. Obrucheva 20-12
Moscow, 117421
FÉDÉRATION DE RUSSIE

Date of mailing (day/month/year) 21 December 1999 (21.12.99)	
Applicant's or agent's file reference 6G-99	**IMPORTANT NOTIFICATION**
International application No. PCT/RU99/00149	International filing date (day/month/year) 30 April 1999 (30.04.99)
International publication date (day/month/year) 11 November 1999 (11.11.99)	Priority date (day/month/year) 30 April 1998 (30.04.98)
Applicant GIVARGIZOV, Evegeny Invievich et al	

1. The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).

2. This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.

3. An **asterisk(*)** appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

4. The **letters "NR"** appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
30 Apri 1998 (30.04.98)	98109078	RU	NR
18 Janu 1999 (18.01.99)	99101033	RU	16 Dece 1999 (16.12.99) *

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

Beatriz Morariu

Telephone No. (41-22) 338.83.38

TENT CO ON TRE Y

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING SUBMISSION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

GIVARGIZOV, Evgeny Invievich
ul. Obrucheva 20-12
Moscow, 117421
FÉDÉRATION DE RUSSIE

Date of mailing (day/month/year) 23 December 1999 (23.12.99)	
Applicant's or agent's file reference 6G-99	**IMPORTANT NOTIFICATION**
International application No. PCT/RU99/00149	International filing date (day/month/year) 30 April 1999 (30.04.99)
International publication date (day/month/year) 11 November 1999 (11.11.99)	Priority date (day/month/year) 30 April 1998 (30.04.98)
Applicant GIVARGIZOV, Evegeny Invievich et al	

1. The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).

2. This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.

3. An **asterisk(*)** appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

4. The **letters "NR"** appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
30 Apri 1998 (30.04.98)	98109078	RU	NR
18 Janu 1999 (18.01.99)	99101033	RU	16 Dece 1999 (16.12.99) *

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

Beatriz Morariu

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING DOCUMENT TRANSMITTED

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as designated Office

Date of mailing (day/month/year)
21 December 1999 (21.12.99)

International application No.
PCT/RU99/00149

International filing date (day/month/year)
30 April 1999 (30.04.99)

Applicant
GIVARGIZOV, Evegeny Invievich et al

The International Bureau transmits herewith the following documents and number thereof:

_____ cop(ies) of priority document(s) (Rule 17.2(a))

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer
Beatriz Morariu

Telephone No.: (41-22) 338.83.38

Copy for the designated Office (DO/US)

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

COMMUNICATION IN CASES FOR WHICH NO OTHER FORM IS APPLICABLE

To:
GIVARGIZOV, Evgeny Invievich
ul. Obrucheva 20-12
Moscow, 117421
FÉDÉRATION DE RUSSIE

Date of mailing (*day/month/year*) 06 December 1999 (06.12.99)	
Applicant's or agent's file reference 6G-99	**REPLY DUE** see paragraph 1 below
International application No. PCT/RU99/00149	International filing date (*day/month/year*) 30 April 1999 (30.04.99)
Applicant GIVARGIZOV, Evegeny Invievich	

1. ☐ REPLY DUE within _____ months/days from the above date of mailing

☐ NO REPLY DUE, however, see below

☒ IMPORTANT COMMUNICATION

☐ INFORMATION ONLY

2. COMMUNICATION:

1. The International Bureau draws the applicant's attention to the following **inconsistency between the priority claim appearing in the request and the corresponding indication in the replacement sheet** which was received by the International Bureau.

Inconsistency with regard to the number of the earlier application:
The request indicates: **98109078 (30 April 1998)**
The substitute sheet indicates: **98108319**

2. Because the time limit prescribed in Rule 26*bis* has expired, the priority claim may no longer be corrected during the international phase. However, the International Bureau will transmit a copy of the priority document to the designated Offices concerned for their consideration upon receipt of a written notice from the applicant. The matter will then need to be taken up by the applicant directly with each designated Office upon entry into the national phase.

3. It is noted that, due to the expiration of the applicable time limit for correction (see item 2), it is the priority claim appearing in the request which has been reflected in the international application as published.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Beatriz Morariu
Facsimile No. (41-22) 740.14.35	Telephone No. (41-22) 338.83.38

Form PCT/IB/345 (July 1992)

Copy for the designated Office (DO/US)

TENT COOPERATION TREATY

PCT

COMMUNICATION IN CASES FOR WHICH NO OTHER FORM IS APPLICABLE

From the INTERNATIONAL BUREAU

To:
GIVARGIZOV, Evgeny Invievich
ul. Obrucheva 20-12
Moscow, 117421
FÉDÉRATION DE RUSSIE

Date of mailing (*day/month/year*) 21 December 1999 (21.12.99)	
Applicant's or agent's file reference 6G-99	~~REPLY DUE~~ see paragraph 1 below
International application No. PCT/RU99/00149	International filing date (*day/month/year*) 30 April 1999 (30.04.99)
Applicant GIVARGIZOV, Evegeny Invievich	

1. ☐ REPLY DUE within _____ months/days from the above date of mailing

☐ NO REPLY DUE, however, see below

☒ IMPORTANT COMMUNICATION

☐ INFORMATION ONLY

2. COMMUNICATION:

1. The International Bureau draws the applicant's attention to the following **inconsistency between the priority claim appearing in the request and the corresponding indication in the priority document** which was received by the International Bureau.

Inconsistency with regard to the number of the earlier application:
The request indicates: **98109078 (30 April 1998)**
The priority document indicates: **98108319**

2. Because the time limit prescribed in Rule 26*bis* has expired, the priority claim may no longer be corrected during the international phase. However, the International Bureau will transmit a copy of the priority document to the designated Offices concerned for their consideration upon receipt of a written notice from the applicant. The matter will then need to be taken up by the applicant directly with each designated Office upon entry into the national phase.

3. It is noted that, due to the expiration of the applicable time limit for correction (see item 2), it is the priority claim appearing in the request which has been reflected in the international application as published.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. (41-22) 740.14.35	Authorized officer Beatriz Morariu Telephone No. (41-22) 338.83.38

Form PCT/IB/345 (July 1992)

TENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
6G-99		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/RU 99/00149	30/04/1999	30/04/1998
Applicant		
GIVARGIZOV, Evgeny Invievich et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. _____

   [ ] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [X] None of the figures.

INTERNATIONAL SEARCH REPORT

[redacted] ational Application No
PCT/RU 99/00149

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01J1/30 H01J9/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 726 589 A (GIVARGIZOV EVGENY INVIEVICH ;STEPANOVA ALLA NIKOLAEVNA (RU); OBOLE) 14 August 1996 (1996-08-14) claims 1-10 ---	1,39
A	EP 0 716 438 A (IBM) 12 June 1996 (1996-06-12) claims 1-14 --- -/--	26,44

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 September 1999	30/09/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Van den Bulcke, E

1

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	GIVARGIZOV E I ET AL: "22.3: A FIELD-EMISSION LAMP BASED ON SI MICROSTRUCTURES WITH DIAMOND COATING FOR LCD BACKLIGHTING" , 1997 SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS, BOSTON, MAY 13 - 15, 1997, NR. VOL. 28, PAGE(S) 369 - 372 , SOCIETY FOR INFORMATION DISPLAY XP000722721 ISSN: 0097-966X page 370 ---	44
A	GIVARGIZOV E L: "ULTRASHARP TIPS FOR FIELD EMISSION APPLICATIONS PREPARED BY THE VAPOR-LIQUID-SOLID GROWTH TECHNIQUE" , JOURNAL OF VACUUM SCIENCE AND TECHNOLOGY: PART B, VOL. 11, NR. 2, PAGE(S) 449 - 453 XP000364847 ISSN: 0734-211X page 449 -page 453 ---	44
A	ZHIRNOV V V ET AL: "CHEMICAL VAPOR DEPOSITION AND PLASMA-ENHANCED CHEMICAL VAPOR DEPOSITION CARBONIZATION OF SILICON MICROTIPS" , JOURNAL OF VACUUM SCIENCE AND TECHNOLOGY: PART B, VOL. 12, NR. 2, PAGE(S) 633 - 637 XP000442745 ISSN: 0734-211X page 633 -page 637 ---	44
A	DE 196 34 193 A (AGENCY IND SCIENCE TECHN) 27 February 1997 (1997-02-27) claims 1-17 ---	1,26
A	WO 89 09479 A (THOMSON CSF) 5 October 1989 (1989-10-05) claims 1,31 ---	1,44
A	EP 0 700 063 A (IBM) 6 March 1996 (1996-03-06) claim 1 ---	1
A	DE 40 41 276 C (SIEMENS) 27 February 1992 (1992-02-27) claim 1 -----	44

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/RU 99/00149

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
EP 0726589	A	14-08-1996	RU	2074444 C	27-02-1997
			JP	9503339 T	31-03-1997
			US	5825122 A	20-10-1998
			WO	9603762 A	08-02-1996
EP 0716438	A	12-06-1996	US	5717278 A	10-02-1998
			US	5791959 A	11-08-1998
DE 19634193	A	27-02-1997	JP	2782587 B	06-08-1998
			JP	9063463 A	07-03-1997
			US	5710478 A	20-01-1998
WO 8909479	A	05-10-1989	FR	2629264 A	29-09-1989
			FR	2644287 A	14-09-1990
			DE	68913419 D	07-04-1994
			DE	68913419 T	01-06-1994
			EP	0365630 A	02-05-1990
			JP	2503728 T	01-11-1990
			US	5090932 A	25-02-1992
EP 0700063	A	06-03-1996	US	5783905 A	21-07-1998
			US	5817201 A	06-10-1998
DE 4041276	C	27-02-1992	DE	59104547 D	23-03-1995
			EP	0493676 A	08-07-1992
			JP	5095140 A	16-04-1993
			US	5188977 A	23-02-1993

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H01J 1/30, 9/02

A1

(11) International Publication Number: WO 99/57743

(43) International Publication Date: 11 November 1999 (11.11.99)

(21) International Application Number: PCT/RU99/00149

(22) International Filing Date: 30 April 1999 (30.04.99)

(30) Priority Data:
98109078 30 April 1998 (30.04.98) RU
99101033 18 January 1999 (18.01.99) RU

(71)(72) Applicant and Inventor: GIVARGIZOV, Evegeny Invievich [RU/RU]; ul. Obrucheva, 20–12, Moscow, 117421 (RU).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): GIVARGIZOV, Michael Evgenievich [RU/RU]; ul. Vargi, 1–115, Moscow, 117133 (RU); ERSHOV, Vladimir Iliich [RU/RU]; ul. Profsojuznaya, 30–2–16, Moscow, 117335 (RU); MANSHINA, Nina Ivanovna [RU/RU]; ul. Polevaya, 19–56, Moskovskaya obl., Fryazino, 141120 (RU).

(81) Designated States: AT, AU, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, HU, IL, IN, JP, KR, LT, LV, PL, RU, SE, SG, SI, SK, UA, US, VN, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: STABILIZED AND CONTROLLED ELECTRON SOURCES, MATRIX SYSTEMS OF THE ELECTRON SOURCES, AND METHOD FOR PRODUCTION THEREOF

(57) Abstract

An electron source is proposed where a field emitter is formed by a whisker grown epitaxially on a substrate. A ballast resistor and an active area are placed in the body and/or on the surface of the field emitter. The ballast resistor can be realized as a barrier in the shape of n–n+, p–p+, p–n semiconductor junctions or insulating layer that crosses the charge carrier flow. Components for controlling such electron sources are arranged vertically. This allows to decrease significantly the area taken by the components, and, in such a way, to increase the resolving power of devices and expand fields of their applications. In so doing, owing to whisker–grown field emitters it is possible to control the emission currents by low voltages at strong electric fields.

STABILIZED AND CONTROLLED ELECTRON SOURCES, MATRIX SYSTEMS OF THE ELECTRON SOURCES, AND METHOD FOR PRODUCTION THEREOF

FIELD OF THE INVENTION

This invention relates to microelectronics, including vacuum microelectronics, in particular to field emission devices, specifically to field emission cathodes, as well as to other field emission devices such as field emission displays, electron sources for electron guns, for microwave devices, etc.

PRIOR ART

During last years, various versions for realization of field emission, including the emission with using of defects in planar structures, are considered, the defect acting as initiators of the field emission [1,2]. Field emitters (tips, blades, etc) prepared by special methods, as field emission initiators, have many advantages in comparison with the defects from the point of view of feasibility to realize regular multiple arrays of the field emitters and controlled growing of the arrays on large areas. However, cases are often occurs at the practice when the regular arrays are inferior to structures with an incidental distribution of the defects in homogeneity.

Troubles in stability and controllability of electron flows giving of by the field emitters are also known. Troubles with uniformity of the field electron emission of the multiple field emitter arrays are of the same nature. The uniformity is typically ensured by ballast resistors that equalize electron currents through different field emitters of the multiple field emitter arrays.

Various design and technological solutions are use for overcoming of the troubles (problems) with the field emitter.

A controlled electron source is known where the field emitter is connected to the drain of MOSFET that serves as a stable current electron source [3,4]. In such an electron source, the issue of stability and controllability of the field emission current is successfully solved. However, transistor p-n junctions in the electron source are placed in the substrate where the field emitter is placed, too, and a control electrode is arranged between the field emitter and a charge carrier source that is placed at the substrate, too. This increases significantly the area taken by a pixel and, accordingly, decreases the resolving power of field emission displays based on such electron sources.

A solution of the problems of stability and controllability combined with the spatial arrangement of the control components is successfully realized in the patent [5]. Here, in the electron source a diode is placed in the emitter base for the stability and the controllability of the field emission

current. Such a design decreases principally the sizes of the electron source three time, as minimum, because its control component takes the same place as the field emitter itself. Such an electron source allows to regulate the voltage so that the starting voltage for the field emission is decreased and, in such a way, the uniform emission is ensured. A plurality of emitters, acting through diodes and operating actually as ballast resistors, are placed onto the cathode electrode. Such a design ensures the uniformity of the field emission and, simultaneously, its controllability. However, the proposed in [5] components of stabilization and control of the field emission current are insufficient for successful solving of the problems of uniformity and controllability.

In the patent [6] a more complete using of the advantages of the field emitters is realized. The field emitter is considered as a spatially distributed object (various parts of which serve as functional components of a device) rather than as a "material point" of the field emission, without spatial characteristics of their various parts.

According to the patent [6] components for control of the electron source are transformed from the planar arrangements, as it was done in [3,4], into a vertical arrangement. Thus, a principal role in the stabilization and control of the field emission current is assigned (allocated), to the body and to the surface of the field emitter, in addition to the usual role of its top.

Similar to [3-5] in the patent [6] an extracting electrode acts to electrons placed in the emitter top. In [6] electron sources are considered where the field emitters have sufficient length and thickness. Therefore, from the point of the action of the control electrodes or barriers (such as the diode in [5]), as minimum four areas of the electron sources are considered:

- the substrate on which the field emitter is placed;
- the basis of the field emitters;
- the top of the field emitters;
- their bodies.

These are areas of selective activation, or active areas.

So, the active area is an area in the substrate, in body of the field emitter, in its basis or at its top. A connection of the source of the charge carriers with the field emitter is implemented through the areas, and a control of the field emission current (of the charge carriers flow) from one area to another by means of stimulation and extracting is implemented.

In some cases, however, such a control of the charge carrier flow can not be realized in [6]. This is related to the fact that the field emitter, being under the action of a rather high electric field, for example, of the anode one, is subjected to its influence not only to the area of the top of field emitter but also all over the body. As a result, such electric field, acting to the field emitter, "shorts out" an action various barriers and over control components. The method for preparation of the field emitters by "wet" or "dry" etching used in the patent [6] results in formation of the emitters having small ratios of the length l of the active area to its diameter d. In this case, for controlling of the field emission current, too large voltage must be used in order to compensate the action of the large external (for example, of anode) electric field.

Indeed, if the field emitter, containing a part with the p-type conductivity is placed in the electric field E (Fig. 3C), formed by the anode, the boundary of the first of the first p-n junction ***04*** is

shifted E_j to the p-area. At a certain value E_t the first junction *04* approaches to the second one *06* in such an extent that the electrons from the n-area *c* begin tunneling through the narrowed barrier to the field emitter. This causes emission of electrons from field emitter. This is the "shorting out" under the external electric field. Existence of the control electrode near the field emitter both in traditional (Fig. 3A) and in the considered [6] version (Fig. 3B) can compensate the action of the penetrating electric field and, such a manner, to "lock" the charge carriers of the second n-area *c*. However, it is known that, at the geometric sizes, considered in [6], the length *l* of the p-area is compatible with or and even shorter than the width *d*. As it is know, for "locking" of the charge carriers value of the traverse electric field of the control electrode *02* or *08* must be comparable with the longitudinal field responsible for the charge carrier flow. This makes it necessary to apply large voltages to the control electrodes.

In addition, in the patent [6] the control electrodes stimulate the flowing of the charge carriers through the active area and extract the electrons from the field emitter. In such a way, the electron emission is stabilized and controlled. At the same time the control electrodes in [6] does not lock the flow of the charge carriers through the active area. The above function of the control electrodes – to stimulate the flowing of the charge carriers, makes it necessary mentioned in [6] approximate sizes of p-area as "... formed to no more than several microns in thickness and generally to submicron order thickness" (see column 8, last paragraph in [6]).This means that the authors of [6] did not consider a possibility to provide the control electrode by "locking" function and, as a result, they considered the design is which enough just for stimulation and which is not enough for locking the electrons move under the influence of strong external electric field. However, it is known that if the control electrodes can lock the flow, it is possible to use small (in absolute value) negative voltage for the locking of the flow. The just mentioned approach is very important from practical point of view – to use low voltage "electric keys" in different driving systems, for example, in the field emission displays. Such a version can not be realized in [6] due to small value of the characteristic l/d that is there approximately equal to 1 which is provided by the design proposed in [6].

In this invention, the drawback is overcome owing to the fact that, here, for stabilization and controlling of the field emission, a whisker ("filament crystal") characterized by l/d>>1 is used. A method for preparation of the whiskers with traverse p-n junctions is also proposed in this invention. As a result, the design proposed allows to control the field emission by locking the charge carrier flow.

The approach proposed is especially important at creation of effective long-living flat panel displays. Indeed, the higher the anode (accelerating) electric field, the more effective and long-living are their phosphors because, the efficiency is larger at higher voltages. Also at the increasing of anode voltage in such devices and, accordingly, decreasing of the current the durability of the phosphors is increased. The high accelerating voltage allows to use a protecting coating layer (for example, aluminum) that prevents the decomposition of the phosphors and increases the illumination owing to the light reflection. In addition, the decreasing currents are useful for the field emitters themselves (especially of semiconductor emitters) because at high currents the emitters are heated resulting in their degradation.

In this invention various possibilities for the stabilization and control of the field emission current based on using of epitaxially grown whiskers are proposed. By whisker growing, the ratio *l/d*

can implemented as 5-10 and more times. In addition, with the whisker grown field emitters broad possibility for shape variation and creation of the control electrodes can be realized. In particular, a design with step-shaped emitter is proposed Fig. 4c.

According to this invention, the field emitter is implemented of whisker that includes at least one barrier (for example, n, n+, p, p+ or p-n junction), e.i., the barrier is placed in the body of the field emitter, being at some height $h>0$ (Fig. 4a) above the substrate, e.i., above its own basis. At the same time in the patents [3,5] one of the barrier is placed at the basis of the field emitter being either at the upper level of the substrate or below it.

As it was mentioned above the active area can be placed both in the basis of field emitter [5], top [3,5] or substrate [3], and in the body of the field emitter [6]. In this invention a version is proposed when the active area is placed on side surface of the field emitter or in the body of the material that has direct or indirect contact with substrate or field emitter.

The active area can be placed also in thin surface conductive layer arranged on an insulating substrate. Thus, the version of the controlling electron source as purposed in this invention not only has solved the problem of transferring the stabilizing and controlling components from their planar arrangement to vertical one (and, in such a way, of increasing the resolution of the device) but also allows to conserve the controllability of the emission current by means of low voltage. In such a way, this allows to realize said controllability both in the case of low and high external electric field.

In the patent [6], as it was mentioned above, the method for fabrication of the field emitters with traverse p-n junctions. However, this method does not allow to obtain optimal geometric parameters of the field emitter that gives necessary functional characteristics.

The methods for growing oriented whiskers arrays are known [7, 8, 9, 10]. The methods, however, does not contain procedures for preparation of the junction, for example, like p-n. In this invention, such procedures are proposed.

SUMMARY OF THE INVENTION

An electron source is proposed, the source including a field emitter, a substrate, a source of charge carriers, and at least one ballast resistor. The field emitter is implemented of a whisker epitaxially grown on the substrate, and at least one ballast resistor is implemented as a barrier which is represented as a boundary in the body of the field emitter. The boundary is formed by a contact of materials with different kinds of conductivity.

In the electron source the field emitter is implemented of at least one semiconductor material. At least one barrier in the electron source is formed by junction of materials with different kinds of conductivity, such as n, n+, p, p+ kinds. At least one barrier is formed by an insulating layer that is across to direction of charge carriers flow.

The field emitters is formed by a tip, the tip consisting of two coaxial parts, a broad lower part and a more narrow upper part. The field emitter can be also formed by a blade. The tops of the field emitters are sharpened and coated by diamond or diamond-like material, and the coatings can be sharpened, too.

At another version of the electron source the barrier is formed by a boundary between a body of the field emitter and a conducting layer placed on a surface of the field emitter. In the electron source, at least one ballast resistor is implemented as a barrier which is represented as a boundary in the field emitter body, the boundary being formed by contacts of the materials with different kinds of conductivity.

The field emitter is implemented of at least one semiconductor material, and the conducting layer is also implemented of at least one semiconductor material.

At least one barrier in the field emitter is formed by junction of materials with different kinds of conductivity, such as n, n+, p, p+ kinds.

In another version of the electron source at least one barrier is formed by an insulating layer that is across to the direction of charge carriers flow.

The field emitter can be formed either by a tip or by a blade. In the case of the tip shape the field emitter consists of two coaxial parts, a broad lower part and a more narrow upper part. The top of the field emitter is sharpened and coated by diamond or diamond-like material, the coating being sharpened, too.

The source of the charge carriers is connected to the field emitter via substrate and/or a conducting layer placed on a surface of the field emitter directly or via an insulating layer.

In one more version of the electron source the substrate has a shape of a tip and is formed by an insulator and by a conductive layer, the ballast resistor being implemented by the layer.

The conductive layer in the electron source contains at least one barrier for charge carriers. At least one barrier in the electron source is formed by junction of materials with different kinds of conductivity, such as n, n+, p, p+ kinds, and at least one barrier is formed by insulating layer that is across to direction of charge carriers flow.

In one more version the electron source can be controlled containing at least one control electrode. The electron source can contain at least one active area in the body and/or on the surface of the field emitter. The active area can be realized in conducting layer placed on the surface of the substrate and/or of the field emitter directly or via an insulator layer.

At least one control electrode is placed close to one barrier for the charge carriers or on side surface of the field emitter via an insulator layer. The control electrode is separated from the field emitter by a vacuum gap or placed along the field emitter. The control electrode can has a direct contact with the side surface of the field emitter.

The substrate in the controlled electron source can be crystalline, or can be implemented by an insulator and a conductive layer placed on the insulator. The substrate can be implemented of the single-crystalline material with orientation (111).

The surface of the substrate can be coated by a material which is transparent for electrons and which prevents outlet of chemical elements from the surface of the controlled electron source, the material being diamond or diamond-like carbon.

The invention is also considered a matrix of the controlled electron sources containing at least two controlled electron sources. The matrix can contain a two-dimensional system of mutually perpendicular rows of the controlled electron sources, at least one of the control electrode of the

electron sources having a diaphragm shape and being implemented of diamond or diamond-like material.

The substrate on which the controlled electron source are arranged is implemented of conductive material placed on an insulator.

The matrix contains conductive buses which form two systems where buses of each of the systems are mutually parallel whereas the buses of two different systems are mutually perpendicular, the systems the two systems being placed in two levels and separated by an insulating layer.

This invention proposes also a method for preparation of controlled electron sources including a formation on a solid substrate of field emitters each of that contains at least one transverse junction formed by materials having different electrical conductivity, a formation of at least one controlled electrode close to such junctions, where the field emitters are implemented of whiskers epitaxially grown by the vapor-liquid-solid mechanism. The implementation of the field emitters can includes formation of the hollows in the substrate and deposition of solvent particles at the bottom of the hollows. The implementation of the field emitters can also includes placing of solvent particles on the substrate and etching of the substrate around the particles.

According to mentioned above the method can includes further procedure for formation of the field emitters, that is to say, placing of a source material, having a first kind of conductivity, opposite to the substrate with the solvent particles on it, growing of whiskers having the first kind of conductivity, stabilized cooling of the grown whiskers, having the globules on its tops, with an introduction of an inert gas into atmosphere, with simultaneous decreasing of the temperature of the substrate, changing of the source material for another source having a second kind of conductivity, stabilized heating of the grown whiskers, having the globules on its tops, with an introduction of an inert gas into atmosphere, with simultaneous increasing of the temperature of the substrate, and growing of whiskers having the second kind of conductivity. The method also include possibility to change the source materials more than two times.

According to mentioned above the method can also includes further procedure for formation of the field emitters includes growing of whiskers in a gaseous atmosphere containing the element or elements of which the substrate consists, introduction of doping gaseous compounds into the gas atmosphere. According to the method the formation of the field emitters can includes more than one procedure of introduction into the gas atmosphere of different gaseous doping compounds.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1. Illustration of the field emission cathode according to the prior art [5].

1 – substrate; 2 – cathode; 3 – diode; 4 – metallic layer; 5 – semiconductor layer; 6 – emitter; 7 – insulating layer; 8 – control electrode.

Fig. 2a, 2b. Illustrations of the field emission devices according to the prior art [3].

Fig. 3a, 3b. Illustrations of the field emission devices according to the prior art [6].

01 – top of field emitter; 02 – control electrode; 03 – insulator; 04 – barrier (junction); 06 – barrier (junction); 08 – control electrode; 09 – conductive part of substrate; 09i – insulator part of substrate; a, b, c – areas of various conductivity kinds; e – position of active areas.

Fig 3c. Illustration of the field emitter with various function areas of the prior art.

E – external electric field; E_j - various positions of junction boundary (for example, p-n) under the influence of external electric fields of various value; E_t – position of junction boundary when electrons start to flow through junction; l – length of the active area; d – width of the active area.

Fig. 3d. Illustration of the method for preparation of the field emitter according to [6].

12, 13, 14 – layers with different kinds of conductivity.

Fig. 4a, 4b, 4c, 4d, 4e. Illustrations of the stabilized electron sources according to the present invention.

q – possible movement of charge carriers; h – height of the position of the barrier above the substrate; 00 – insulator if charge carriers are provided via surface layer; 00 – conductive material if charge carriers are provided via substrate.

Fig. 5a, 5b, 5c, 5d. Illustrations of the controlled electron sources according to the present invention

Fig. 6a. Illustration of the matrix system of the controlled electron sources according to the present invention.

07 – aperture.

Rows of control electrodes 02 and 08 are mutually perpendicular , and together realize the controlling of the emission of the matrix system.

Fig. 6b. Illustration of the matrix system of the controlled electron sources according to the present invention.

Rows of control electrodes 02 and rows of conductive stripes 09 of substrate based on insulate part 09i of the substrate are mutually perpendicular , and together realize the controlling of the emission of the matrix system.

Fig. 7. Illustration of grown silicon whisker with transversal barriers (junctions)

15 – solidified globule consisting of crystallites of silicon and solvent; by acting to the whisker with a chemical etch of silicon, the whisker is transformed into tip with simultaneous removal of the globule.

BEST VERSION FOR REALIZATION OF THE INVENTION.

EXAMPLE 1. A most typical version for realization of the stabilized electron sources that uses a barrier as a ballast resistor is the following. A thin layer of n-type silicon is deposited onto p-type silicon tip that epitaxial to substrate (Fig. 4d). The junction between the p-type of silicon and the n-type silicon coating acts as a ballast resistor.

EXAMPLE 2. A most typical version for realization of the controlled electron sources that uses a vertical arrangement of the control components is the following. The tip contains in its body two p-n junctions. An upper part of the tip is implemented of n-type material. A lower part of the tip as well

as the adjacent substrate are implemented of n-type material. A control electrode is placed at a middle part of the tip which is implemented of p-type material. The control electrode has an extended length, is placed on the surface of the tip and has with it a direct contact (Fig. 5c). When a voltage V_{open} is applied to the control electrode, an inverse layer is induced at the area *b* along the surface of the field emitter, and electrons from the area *c* begin to penetrate into area *a* through the inverse layer. Then the electrons are emitting from the field emitters under the action of the anode voltage.

EXAMPLE 3. A most typical version for realization of the matrix system of the controlled electron sources that uses the vertical arrangement of the control components is the following.

Rows of sharpened whisker-grown field emitters 01 are formed on a conducting substrate 09 of silicon having the crystallographic orientation (111), see Fig. 6a. A system of parallel rows of control electrodes 08 is formed on the surface of the field emitters, the insulating layers 03 being placed between the field emitters and the control electrodes. Then, an insulating glass layer 03' is deposited on the structure. After that, a set of parallel stripes 02 is deposited onto the glass, and centro-symmetrical cavities 07 are formed at the places corresponding to the emitters so that the upper ("top") of each of the emitters are in the centers of the cavities being risen above their bottoms. It important that the set of the stripes 02 is perpendicular to the system of parallel rows of the control electrode 08. In order to obtain an emission from a given field emitter, it is necessary to apply a voltage V_{open} to a row in the system of the control electrodes 08 and, simultaneously, to apply a voltage V_{ext} to a stripe in the set 02. At the cross of the row and of the stripe, the sum voltage $V_{open} + V_{ext}$ initiates the emission.

REFERENCES

1. I.Brodie, P.R.Schwoebel, Vacuum Microelectronic Devices,
Proceedings of the IEEE, Vol. 82, No. 7, July 1994

2. W.Zhu, G.P.Kochanski, S.Jin and L.Siebles,
J.Appl.Phys., 78 (1995) 2707

3. H.F. Gray, Regulatable field emitter device and method of production thereof,
US Pat. 5 359 256, Cl 313/169 (1994).

4. Junji Itoh, Takayuki Hirano, and Seigo Kanemaru, Ultrastable emission from a metal-oxide-semiconductor field-effect transistor-structured Si emitter tip,
Appl.Phys.Lett. 69 (11), 9 September 1996, p. 1577

5. Yoichi Kobori, Mitsuru Tanaka, Field emission cathode,
US Pat. 5 162 704, Cl 315/349 (1992).

6. Seigo Kanemaru, Junji Itoh, Field emitter having source, channel, and drain layers,
US Patent 5,710,478, Date of patent 20.01.1998

7. E.I.Givargizov, Method and apparatus for growing oriented whisker arrays,
RU Patent 2.099.808, 20.12.1997г.

8. Yoshinori Terui, Ryuichi Terasaki, Method for producing single crystal, and needle-like single crystal, US Patent # 5,544,617 Date of patent 13.08.1996

9. Didier Pribat et al, Method for the controlled growth of crystal whiskers and application thereof to the making of tip microcathodes.

10. Michio Okajima et al, Fabrication method of fine structures,
US Patent 5,381,753 Date of patent 17.01.1995

CLAIMS

1. An electron source that includes a field emitter, a substrate, a source of charge carriers, at least one ballast resistor, wherein

the field emitter is implemented of a whisker epitaxially grown on the substrate;

at least one ballast resistor is implemented as a barrier which is represented as a boundary in the body of the field emitter , the boundary being formed by contact of materials with different kinds of conductivity.

2. The electron source according to the claim 1, wherein the field emitter is implemented of at least one semiconductor material.

3. The electron source according to the claim 2, wherein at least one barrier is formed by junction of materials with different kinds of conductivity, such as n, n^-, p, p^- kinds.

4. The electron source according to any of the claims 1-3, wherein at least one barrier is formed by an insulating layer that is across to the direction of the charge carriers flow.

5. The electron source according to any of the claims 1-4, wherein the field emitter is formed by a tip.

6. The electron source according to any of the claims 1-5, wherein the field emitter consists of two coaxial parts, a broad lower part and a more narrow upper part.

7. The electron source according to any of the claims 1-4, wherein the field emitter is formed by a blade.

8. The electron source according to any of the claims 1-7, wherein the top of the field emitter is sharpened and coated by diamond or diamond-like material.

9. The electron source according to the claim 8, wherein the diamond or diamond-like coating is sharpened.

10. An electron source that includes a field emitter, a substrate, a source of charge carriers, at least one ballast resistor, wherein

the field emitter is implemented of a whisker epitaxially grown on the substrate;

at least one ballast resistor is implemented as a barrier formed by a boundary between a field emitter body and a conducting layer placed on a surface of the field emitter.

11. The electron source according to the claim 10, wherein at least one ballast resistor is implemented as a barrier which is represented as a boundary in field emitter body, the boundary being formed by contact of the materials with different kinds of conductivity.

12. The electron source according to any of the claims 10, 11, wherein the field emitter is implemented of at least one semiconductor material.

13. The electron source according to any of the claims 10-12, wherein the conducting layer is implemented of at least one semiconductor material.

14. The electron source according to any of the claims 10-13, wherein at least one barrier is formed by junction of materials with different kinds of conductivity, such as n, n^-, p, p^- kinds.

15. The electron source according to any of the claims 10-14, wherein at least one barrier is formed by insulating layer that is across to direction of charge carriers flow.

16. The electron source according to any of the claims 10-15, wherein the field emitter is formed by a tip.

17. The electron source according to any of the claims 10-16, wherein the field emitter consists of two coaxial parts, a broad lower part and a more narrow upper part.

18. The electron source according to any of the claims 10-15, wherein the field emitter is formed by a blade.

19. The electron source according to any of the claims 10-18, wherein the top of the field emitter is sharpened and coated by diamond or diamond-like material.

20. The electron source according to the claim 19, wherein the diamond or diamond-like coating is sharpened.

21. The electron source according to any of the claims 10-20, wherein the source of the charge carriers is connected to field emitter via substrate and/or a conducting layer placed on a surface of the field emitter directly or via an insulator layer.

22. An electron source that includes a field emitter, a substrate, a source of charge carriers, at least one ballast resistor, wherein

the substrate has a shape of a tip and is formed by insulator and by a conductive layer;

the ballast resistor is implemented by the layer.

23. The electron source according to the claim 22, wherein the conductive layer contains at least one barrier for charge carriers.

24. The electron source according to any of the claims 22, 23, wherein at least one barrier is formed by junction of materials with different kinds of conductivity, such as n, n^+, p, p^+ kinds.

25. The electron source according to any of the claims 22-24, wherein at least one barrier is formed by insulating layer that is across to direction of charge carriers flow.

26. A controlled electron source that includes a field emitter, a substrate, a source of charge carriers, at least one ballast resistor and at least one control electrode, wherein

it contains an electron source implemented according to claims 1-25.

27. The controlled electron source according to the claim 26, wherein it contains at least one active area in the body and/or on the surface of the field emitter.

28. The controlled electron source according to any of the claims 26, 27, wherein it contains at least one active area in a conducting layer placed on the surface of the substrate and/or of the field emitter directly or via an insulator layer.

29. The controlled electron source according to any of the claims 26-28, wherein at least one control electrode is placed close to one of the barrier for charge carriers.

30. The controlled electron source according to any of the claims 26-29, wherein at least one control electrode placed on side surface of the field emitter via an insulator layer.

31. The controlled electron source according to any of the claims 26-30, wherein it contains at least one control electrode that is separated from the field emitter by a vacuum gap.

32. The controlled electron source according to any of the claims 26-31, wherein at least one control electrode placed along the field emitter.

33. The controlled electron source according to any of the claims 26-32, wherein control electrode has a direct contact with the side surface of the field emitter.

34. The controlled electron source according to any of the claims 26-33, wherein the electron source according to any of the claims 1-21 a substrate is crystalline.

35. The controlled electron source according to any of the claims 26-34, wherein the electron source according to any of the claims 1-21 a substrate is implemented by an insulator and a conductive layer placed on the insulator.

36. The controlled electron source according to any of the claims 34, 35, wherein the substrate or the conductive layer of the substrate is implemented of the monocrystalline material with orientation (111).

37. The controlled electron source according to any of the claims 26-36, wherein its surface is coated by a material which is transparent for electrons, and which prevents outlet of chemical elements from the surface of controlled electron source.

38. The controlled electron source according to the claim 37, wherein the material is diamond or diamond-like carbon.

39. A matrix system of the controlled electron sources containing at least two controlled electron sources, wherein

at least one of the sources implemented according to any of the claims 26-38.

40. The matrix system according to the claim 39, wherein it contains a two-dimensional system of mutually perpendicular rows of the controlled electron sources.

41. The matrix system according to any of the claims 39, 40, wherein at least one control electrode in the controlled electron sources has a diaphragm shape and is implemented of conductive diamond or diamond-like material.

42. The matrix system according to any of the claims 39-41, wherein the substrate represents rows of conductive material placed on insulator.

43. The matrix system according to any of the claims 39-42, wherein the controlled electron sources are provided by conductive buses which form two systems buses of each of the systems are mutually parallel, the buses of the two different systems are mutually perpendicular, the two systems being placed in two levels and separated by insulator.

44. A method for preparation of controlled electron sources including

a formation on a solid substrate of field emitters each of that contains at least one transverse junction formed by materials having different electrical conductivity;

a formation of at least one controlled electrode close to such junctions;

wherein

the field emitters are implemented of whiskers epitaxially grown by the vapor-liquid-solid mechanism.

45. The method according to the claim 44, wherein the implementation of the field emitters includes

formation of the hollows in the substrate;

deposition of solvent particles at the bottom of the hollows.

46. The method according to the claim 44, wherein the implementation of the field emitters includes

placing of solvent particles on the substrate;

etching of the substrate around the particles.

47. The method according to any of the claims 45, 46, wherein further procedure for formation of the field emitters includes

placing of a source material, having a first kind of conductivity, opposite to the substrate with the solvent particles on it;

growing of whiskers having the first kind of conductivity;

stabilized cooling of the grown whiskers, having the globules on its tops, with an introduction of an inert gas into atmosphere, with simultaneous decreasing of the temperature of the substrate;

changing of the source material for another source having a second kind of conductivity;

stabilized heating of the grown whiskers, having the globules on its tops, with an introduction of an inert gas into atmosphere, with simultaneous increasing of the temperature of the substrate;

growing of whiskers having the second kind of conductivity;

48. The method according to the claim 47, wherein the change of the source materials is implemented more than two times.

49. The method according to any of the claims 45, 46, wherein further procedure for formation of the field emitters includes

growing of whiskers in a gaseous atmosphere containing the element or elements of which the substrate consists;

introduction of doping gaseous compounds into the gas atmosphere.

50. The method according to the claim 49, wherein the formation of the field emitters includes more than one procedure of introduction into the gas atmosphere of different gaseous doping compounds.

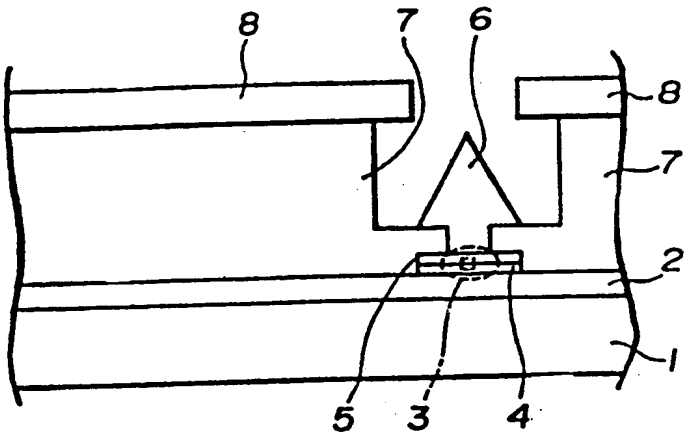


Fig. 1

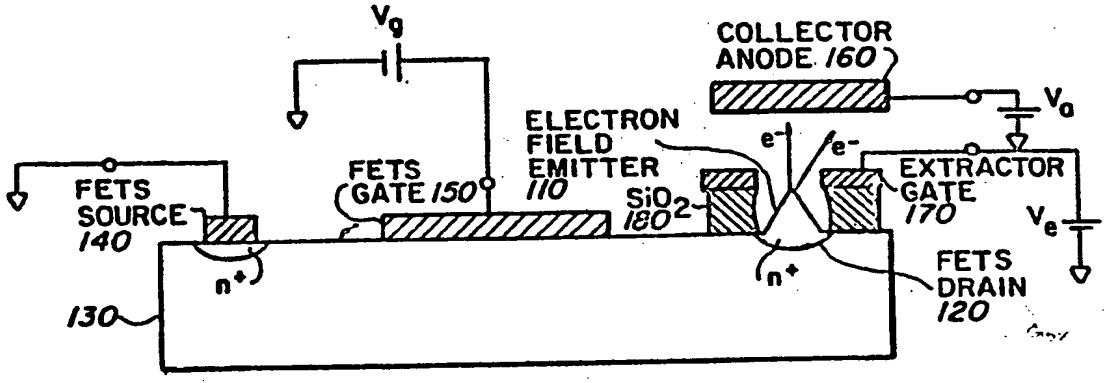


Fig. 2a

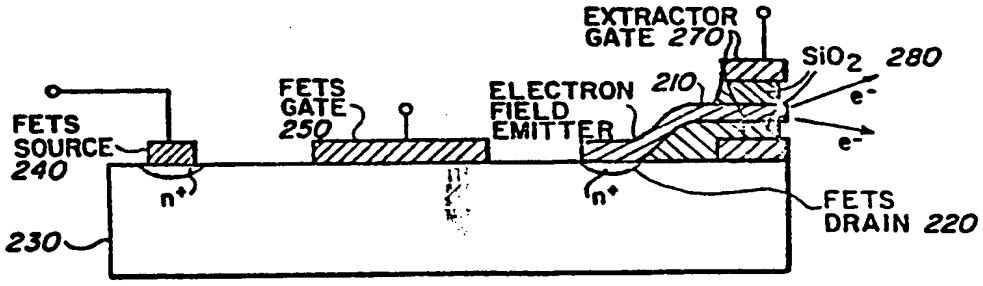


Fig. 2b

Fig. 3a

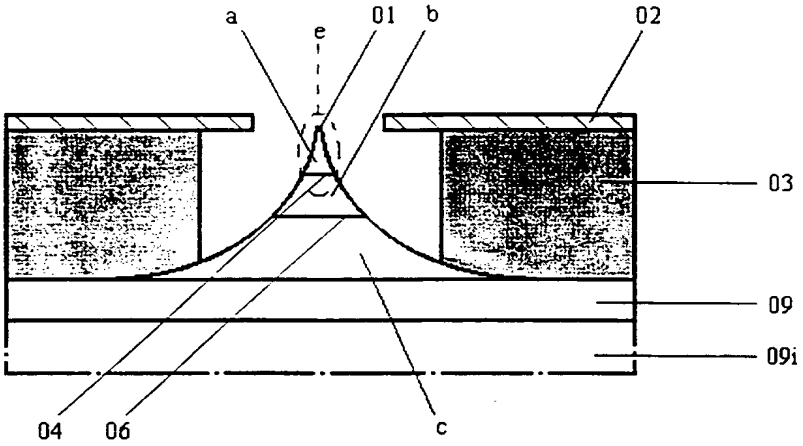


Fig. 3b

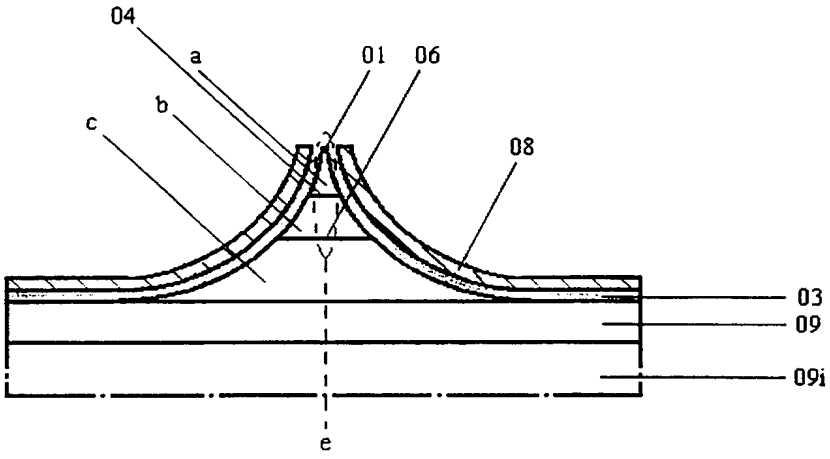


Fig. 3c

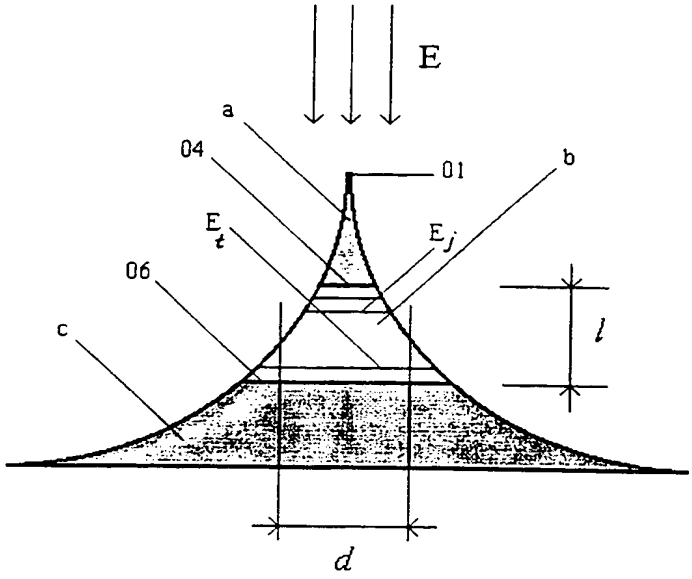
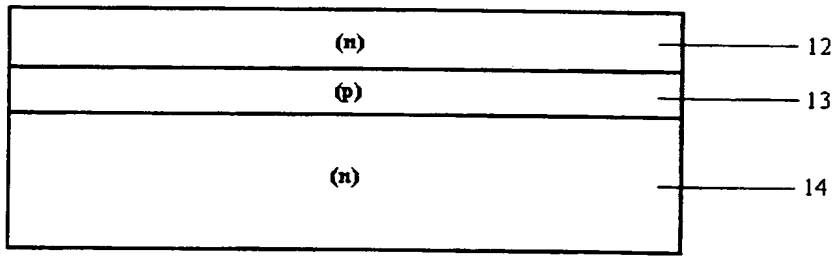


Fig. 3d



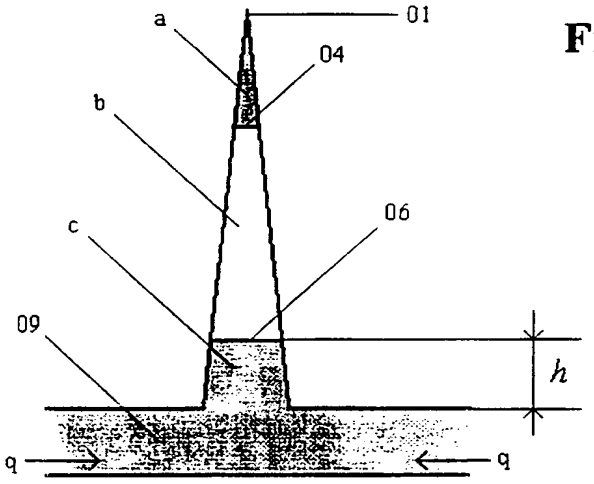


Fig. 4a

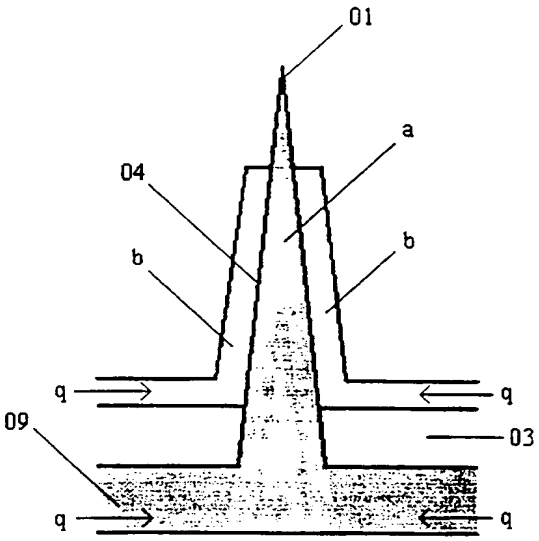
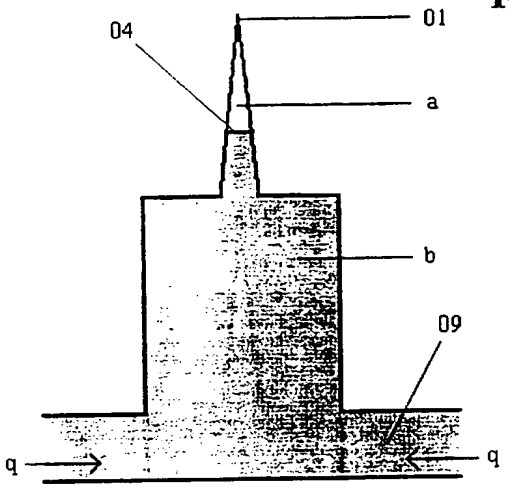


Fig. 4b

Fig. 4c



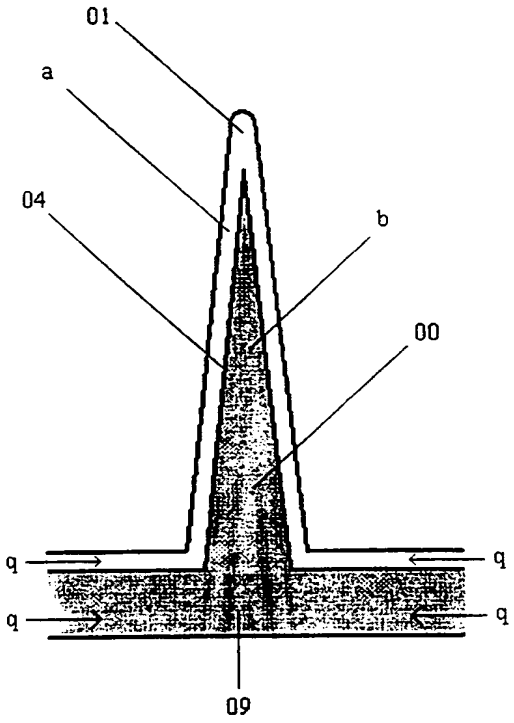


Fig. 4d

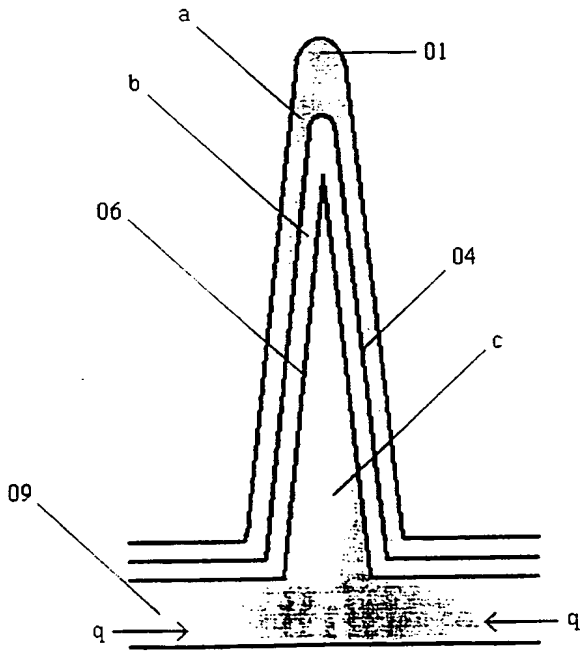


Fig. 4e

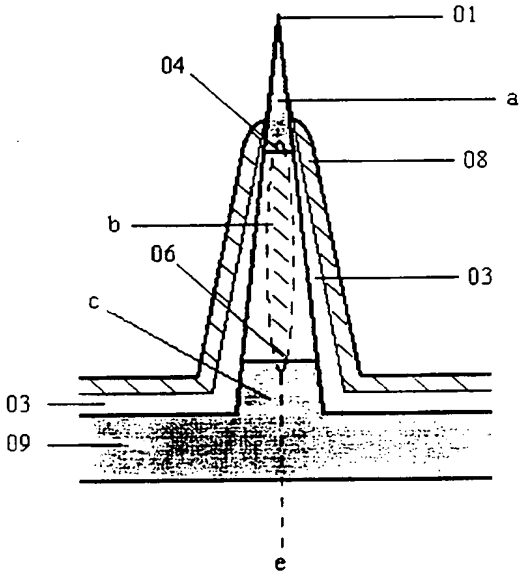


Fig. 5a

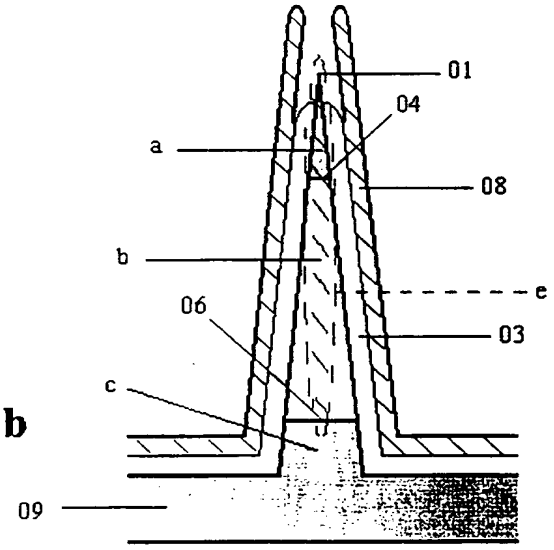


Fig. 5b

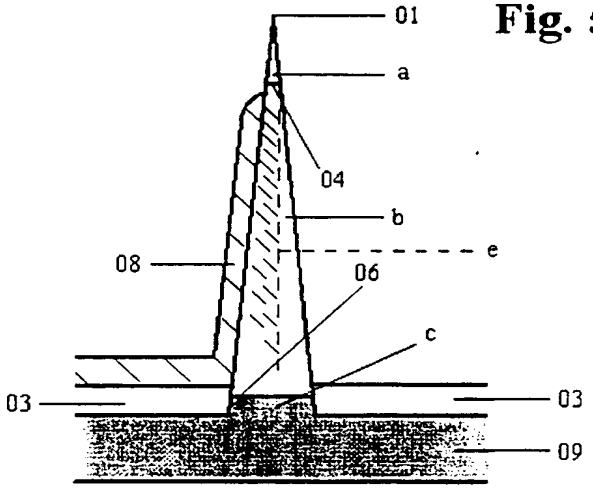


Fig. 5c

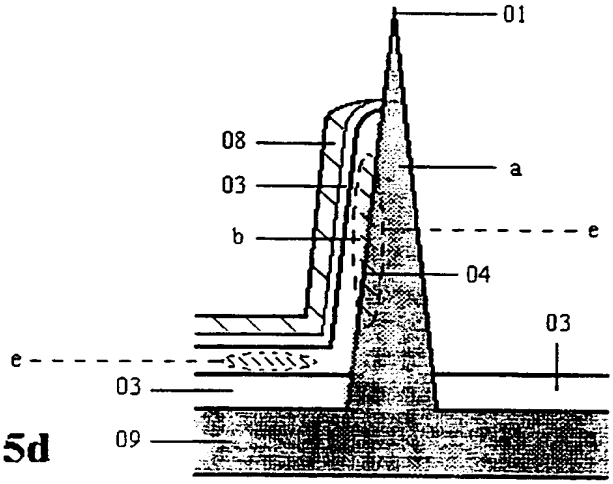


Fig. 5d

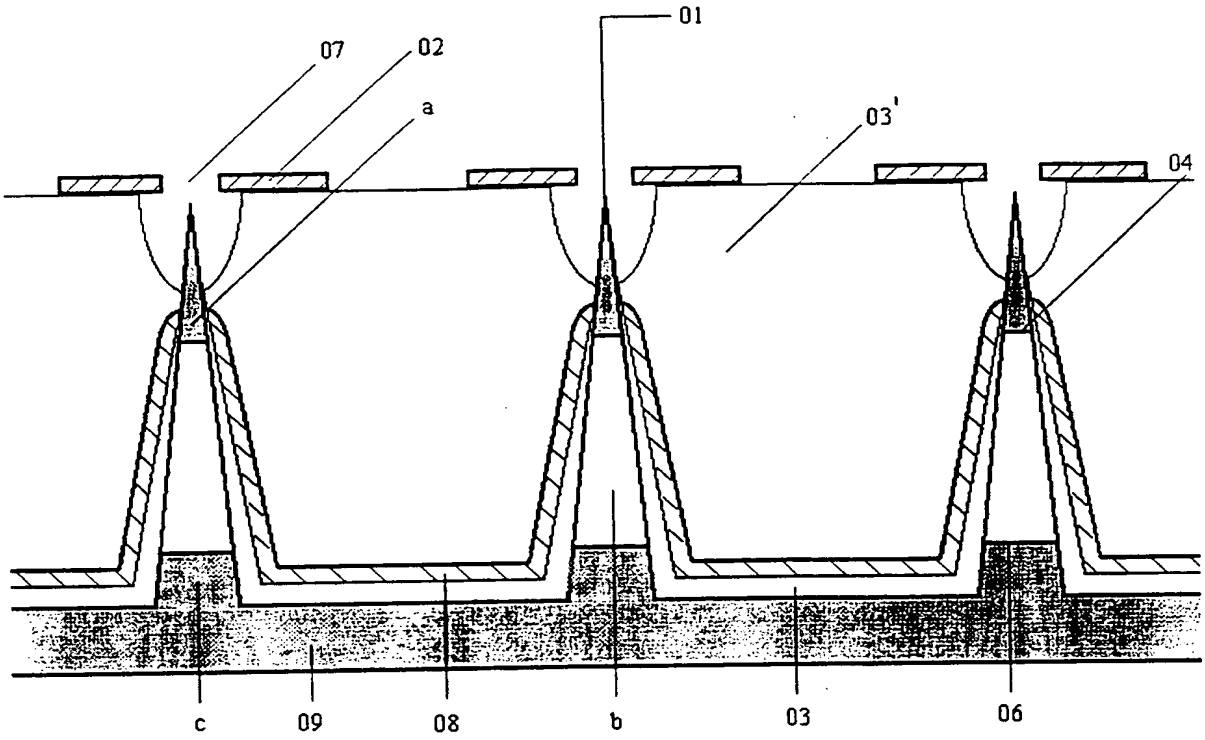


Fig. 6 a

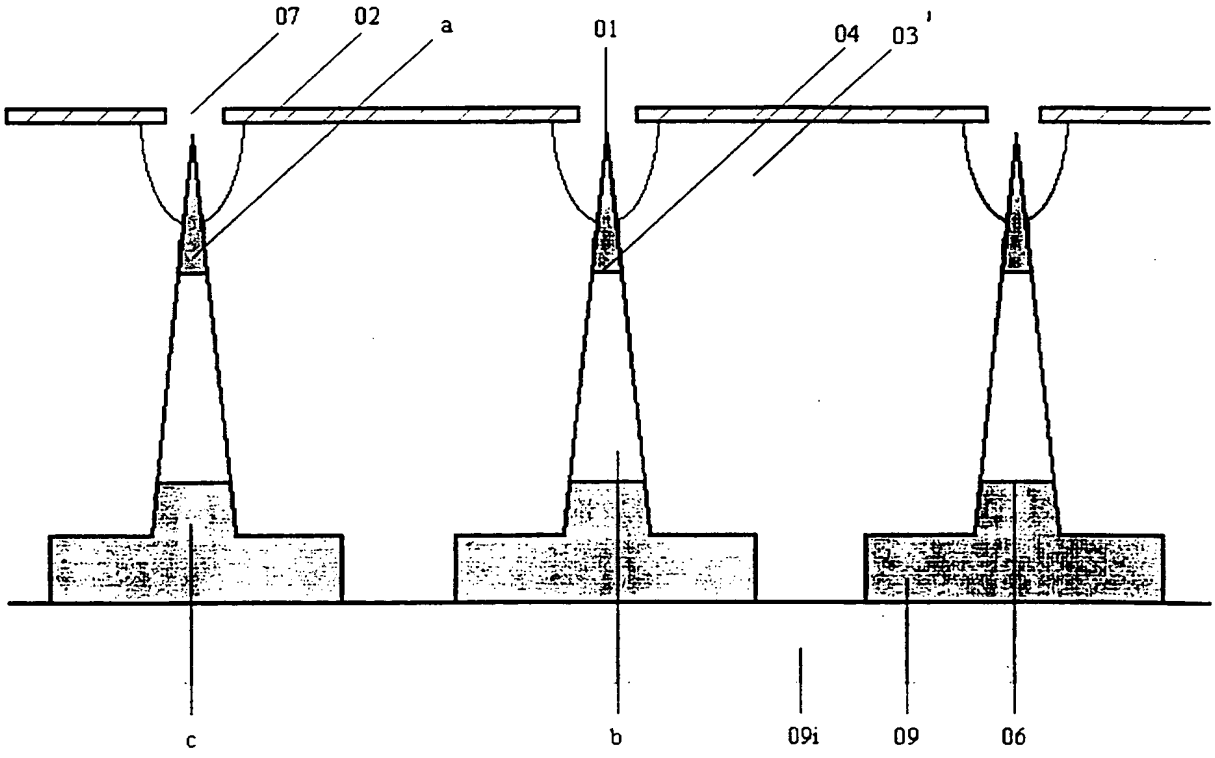


Fig. 6b

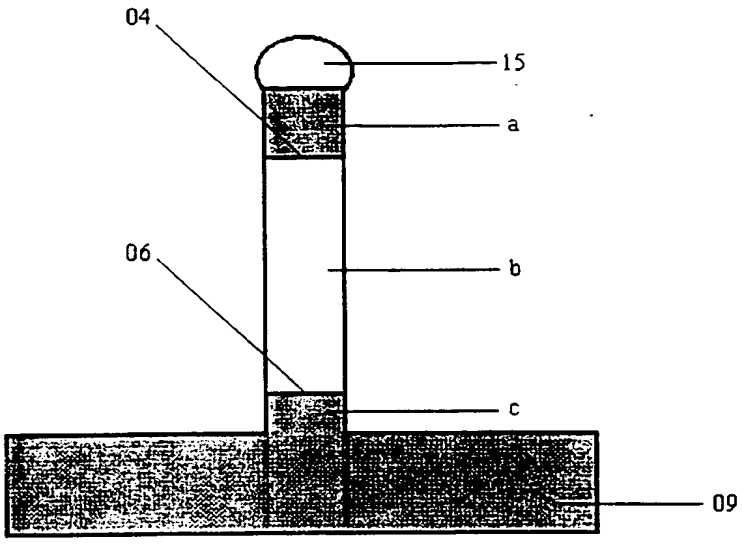


Fig. 7

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/RU 99/00149

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01J1/30 H01J9/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 726 589 A (GIVARGIZOV EVGENY INVIEVICH ;STEPANOVA ALLA NIKOLAEVNA (RU); OBOLE) 14 August 1996 (1996-08-14) claims 1-10 ---	1,39
A	EP 0 716 438 A (IBM) 12 June 1996 (1996-06-12) claims 1-14 --- -/--	26,44

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 September 1999	30/09/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office. P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040. Tx. 31 651 epo nl. Fax: (+31–70) 340–3016	Van den Bulcke, E

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GIVARGIZOV E I ET AL: "22.3: A FIELD-EMISSION LAMP BASED ON SI MICROSTRUCTURES WITH DIAMOND COATING FOR LCD BACKLIGHTING" , 1997 SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS, BOSTON, MAY 13 - 15, 1997, NR. VOL. 28, PAGE(S) 369 - 372 , SOCIETY FOR INFORMATION DISPLAY XP000722721 ISSN: 0097-966X page 370 ---	44
A	GIVARGIZOV E L: "ULTRASHARP TIPS FOR FIELD EMISSION APPLICATIONS PREPARED BY THE VAPOR-LIQUID-SOLID GROWTH TECHNIQUE" , JOURNAL OF VACUUM SCIENCE AND TECHNOLOGY: PART B, VOL. 11, NR. 2, PAGE(S) 449 - 453 XP000364847 ISSN: 0734-211X page 449 -page 453 ---	44
A	ZHIRNOV V V ET AL: "CHEMICAL VAPOR DEPOSITION AND PLASMA-ENHANCED CHEMICAL VAPOR DEPOSITION CARBONIZATION OF SILICON MICROTIPS" , JOURNAL OF VACUUM SCIENCE AND TECHNOLOGY: PART B, VOL. 12, NR. 2, PAGE(S) 633 - 637 XP000442745 ISSN: 0734-211X page 633 -page 637 ---	44
A	DE 196 34 193 A (AGENCY IND SCIENCE TECHN) 27 February 1997 (1997-02-27) claims 1-17 ---	1,26
A	WO 89 09479 A (THOMSON CSF) 5 October 1989 (1989-10-05) claims 1,31 ---	1,44
A	EP 0 700 063 A (IBM) 6 March 1996 (1996-03-06) claim 1 ---	1
A	DE 40 41 276 C (SIEMENS) 27 February 1992 (1992-02-27) claim 1 -----	44

INTE[redacted]TIONAL SEARCH REPORT

ormation on patent family members

Interr[redacted]nal Application No
PCT/RU 99/00149

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0726589 A	14-08-1996	RU 2074444 C	27-02-1997
		JP 9503339 T	31-03-1997
		US 5825122 A	20-10-1998
		WO 9603762 A	08-02-1996
EP 0716438 A	12-06-1996	US 5717278 A	10-02-1998
		US 5791959 A	11-08-1998
DE 19634193 A	27-02-1997	JP 2782587 B	06-08-1998
		JP 9063463 A	07-03-1997
		US 5710478 A	20-01-1998
WO 8909479 A	05-10-1989	FR 2629264 A	29-09-1989
		FR 2644287 A	14-09-1990
		DE 68913419 D	07-04-1994
		DE 68913419 T	01-06-1994
		EP 0365630 A	02-05-1990
		JP 2503728 T	01-11-1990
		US 5090932 A	25-02-1992
EP 0700063 A	06-03-1996	US 5783905 A	21-07-1998
		US 5817201 A	06-10-1998
DE 4041276 C	27-02-1992	DE 59104547 D	23-03-1995
		EP 0493676 A	08-07-1992
		JP 5095140 A	16-04-1993
		US 5188977 A	23-02-1993